



Cisco research indicates that the total volume of worldwide IP traffic is doubling every two years.

By 2011, the world's IP networks will transport 29 exabytes of traffic . equivalent to 144 times the total amount of printed matter that exists today. ò ò .. each month!

WELCOME TO THE ZETA BYTE ERA!





The ZetaByte Era and The (R)evolution of the Transport Network



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Public Sector: Digital Cities, NReN

SP NGN (Core/Edge, Access/Aggregation and Optical)



Routing and Switching #15661

Agenda

- Evolution of transport networks
- Explosion in internet traffic
- Basics of a DWDM system
- Revolution of transport networks with IPoDWDM (An introduction)
- IPoDWDM benefits and Case studies
- Future Developments

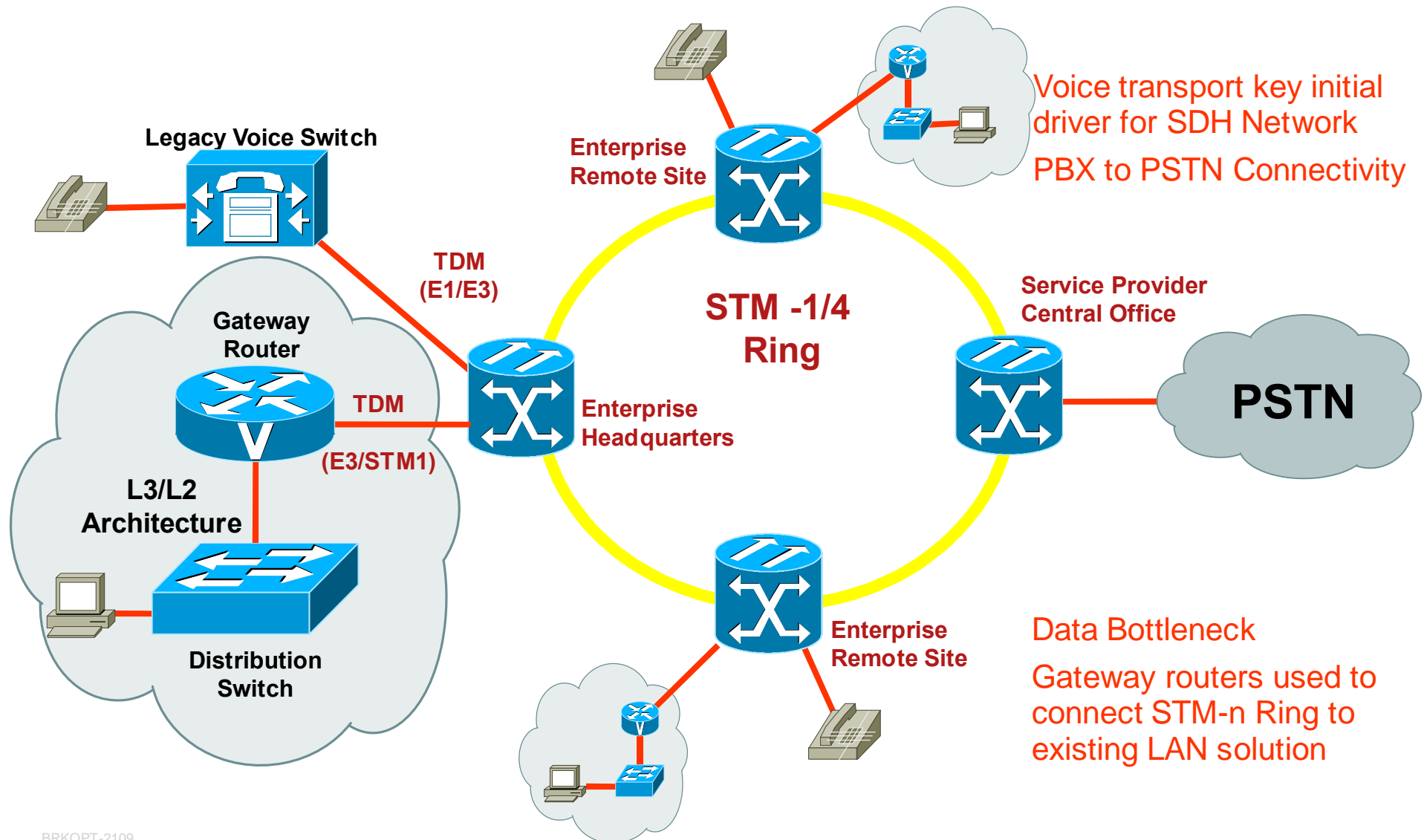




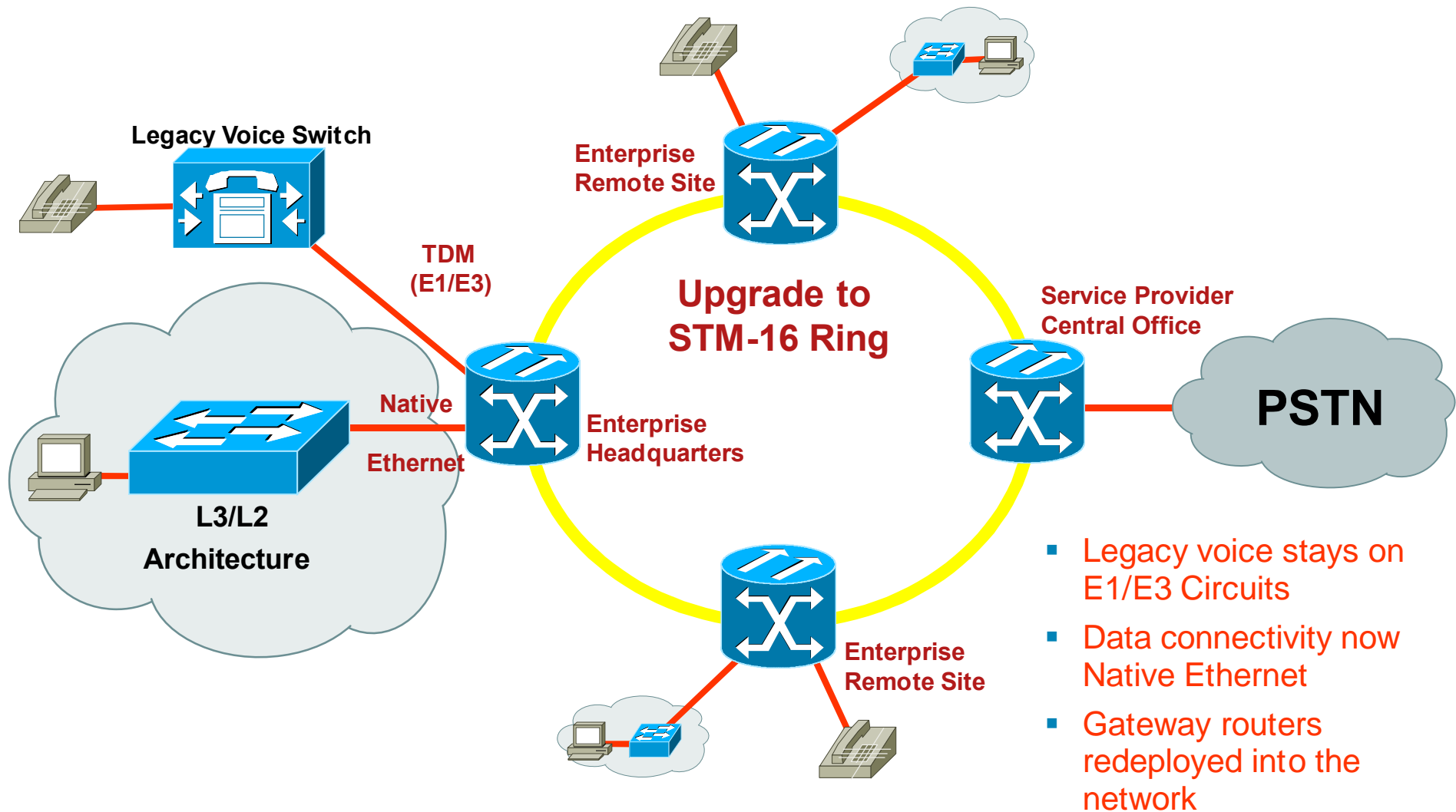
Optical Network Evolution



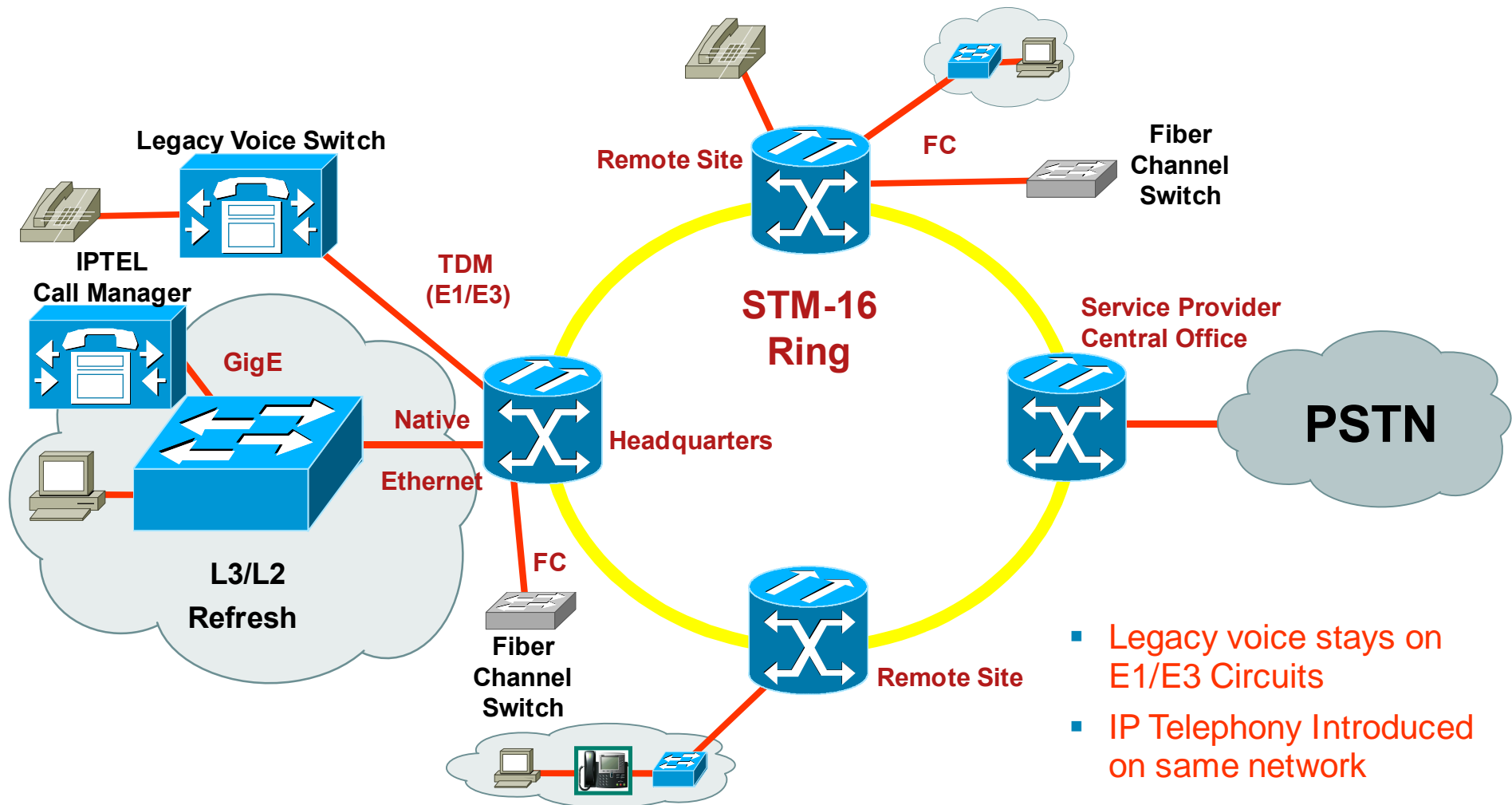
Layer 1 Service Example – Transporting TDM/Data via Legacy SDH



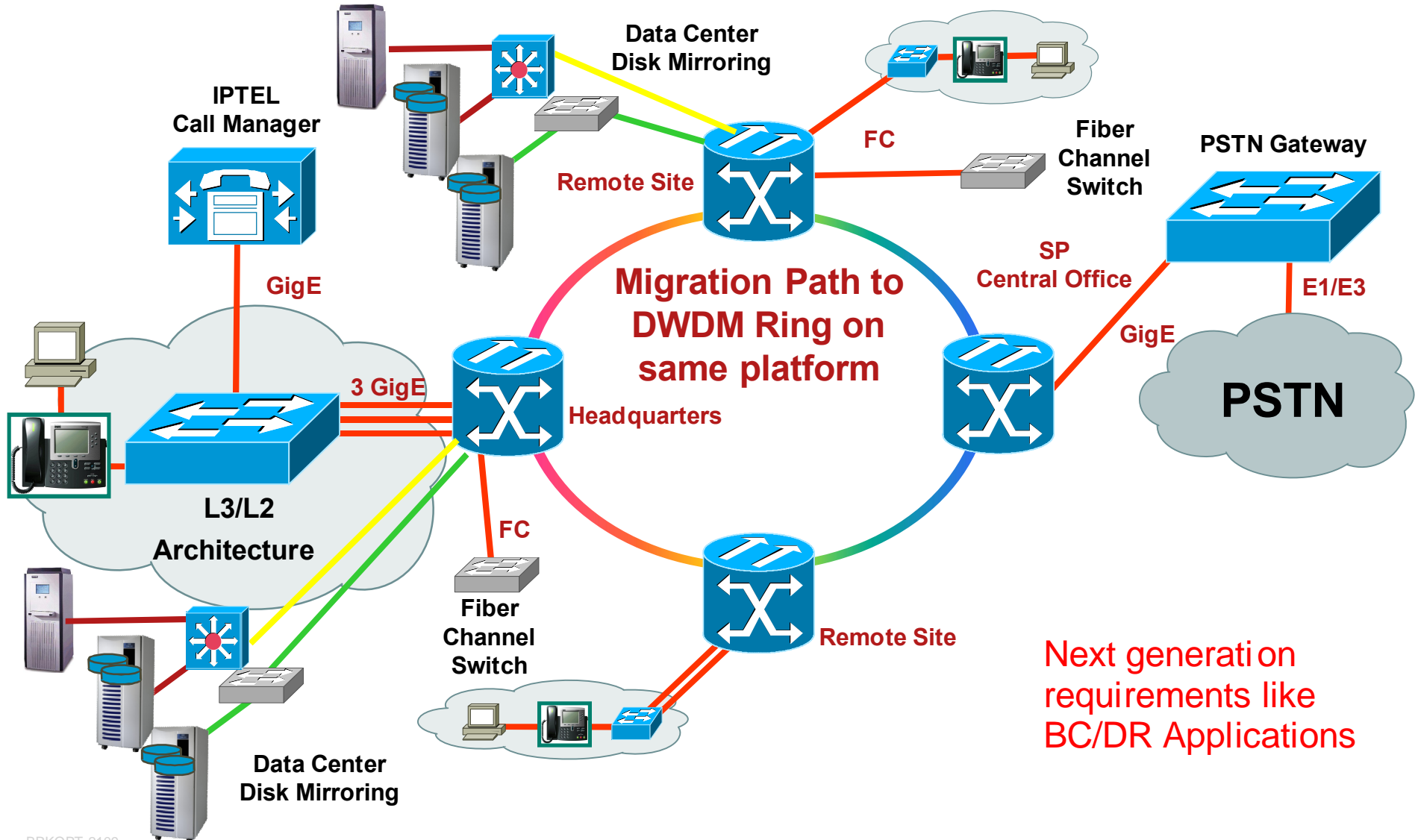
Evolving the network to support the unknown...



Paving the way for flexibility!



Network Optimization



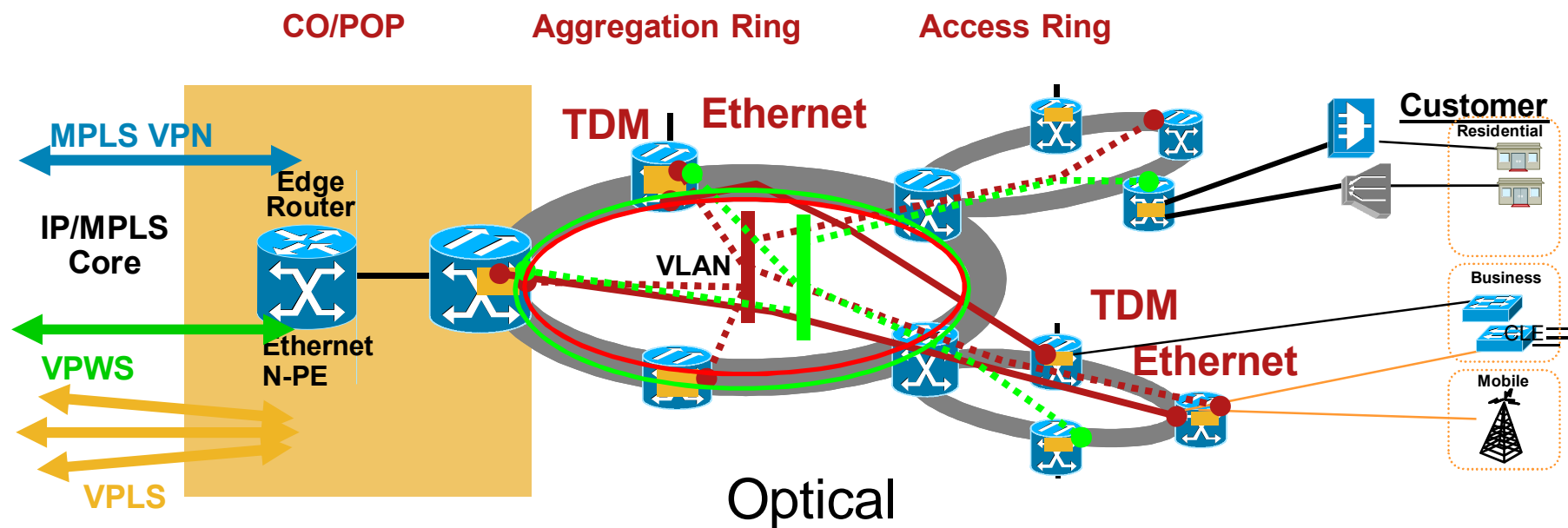
Next generation requirements like BC/DR Applications

Benefits of an SDH Approach

- Transport networks today are based on SONET/SDH because it offers:
 1. Operational efficiency (OAM&P)
 2. Fast protection (< 50 ms, as originally designed for voice circuits)
 3. Efficient grooming at the sub-wavelength level
- However, number three is no longer valid:

Due to traffic growth, it is now cost-effective to carry router-to-router traffic over a dedicated wavelength

Optical Network Transition to IP NGN



Legacy – Maintain revenue streams

Interface and Service Transition - from TDM to Ethernet

Networking Transition – Packet flows are networked as VLANs

WDM – Scale beyond 10G with Ethernet services (EoWDM)

Legacy Transport Inefficiencies NextGen SDH

The Business Case for Carrier Ethernet

- Protocol Inefficiencies at higher bit rates 10GE
- SDH technology, an always-on transport that is much more expensive per bit than Ethernet traffic.
- NextGen SDH standards have not yet been able to keep up support for new optical services, including storage protocols (ESCON, FICON, Fibre Channel, etc.) and even video, nor have they been able to address support for the increasingly **important Ethernet 10G LAN PHY**.

**DWDM Everywhere
(Services and Transport)**

Legacy Transport Inefficiencies NextGen SDH

The Business Case for Carrier Ethernet

- With SDH, increasing the speed of even one ring from STM1 to STM4 could adversely affect the other rings.
- Analysis shows As operators and standards bodies look for ways to support new services on SDH networks, both the cost and the network complexity grow with little added value.
- As a result TDM services will remain flat to declining, indicating that those services are migrating to packet as well. (See Next Slide)

**DWDM Everywhere
(Services and Transport)**

SDH Market Outlook

MARKET ANALYSIS

Worldwide Optical Networking 2008–2012 Forecast and Analysis

- ☒ Clearly, the demand for traditional SONET/SDH equipment has declined and is being replaced with MSPPs. Embedded and integrated cross-connect capabilities, such as ADM on a chip, are prevalent in MSPPs as well as data services with native Ethernet being framed with GFP. In many cases, mini-MSPP/MSTPs are being delivered for interoffice or regional connectivity, consisting of low wavelength counts but high enough bandwidth for transmission. Smaller footprints, lower cost, and reduced switching at the central office are all drivers for MSPP purchasing. IDC has reduced the forecast for MSPPs with the intention that these products will migrate into metro-like ROADM products with MSPP access features. Although we do note that MSPPs are still being widely deployed for wireless backhaul in APAC, supporting this market for a while. In addition, new products such as Fujitsu's 9500 support multiple SONET/SDH ring capacities, extending the definition of what an MSPP is capable of.

Worldwide Optical Networking Revenue by Segment, 2005–2012 (\$M)

	2005	2006	2007	2008	2009	2010	2011	2012	2007–2012 CAGR (%)
SONET/ SDH	1,477.7	1,596.1	1,111.3	911.2	801.9	657.5	578.6	474.5	-15.7
Growth (%)	NA	8.0	-30.4	-18.0	-12.0	-18.0	-12.0	-18.0	
Share (%)	15.3	14.1	7.8	5.9	4.8	3.7	3.1	2.5	



Re-Thinking the Core Transport with IPoDWDM



Video Apps Approach the Zettabyte Era

Increasingly Bandwidth Intensive and Complex



44 Exabytes per month Total Traffic by 2012

2012 annual bandwidth demand reaches 522 Exabytes, or more than half of a Zettabyte

Residential HD Video



Bi-Directional Mobile Video



Massive Online Video Storage Libraries



Business HD and 3-D Video

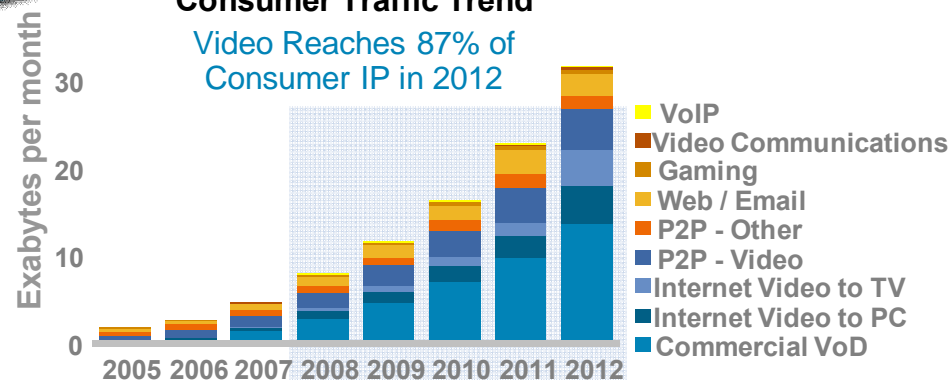


Personalized Event Driven Content



Consumer Traffic Trend

Video Reaches 87% of Consumer IP in 2012



Source: Cisco, 2008

Overall Traffic Growth Is Straining All Known Network Architectures

Global IP Traffic—By Segment

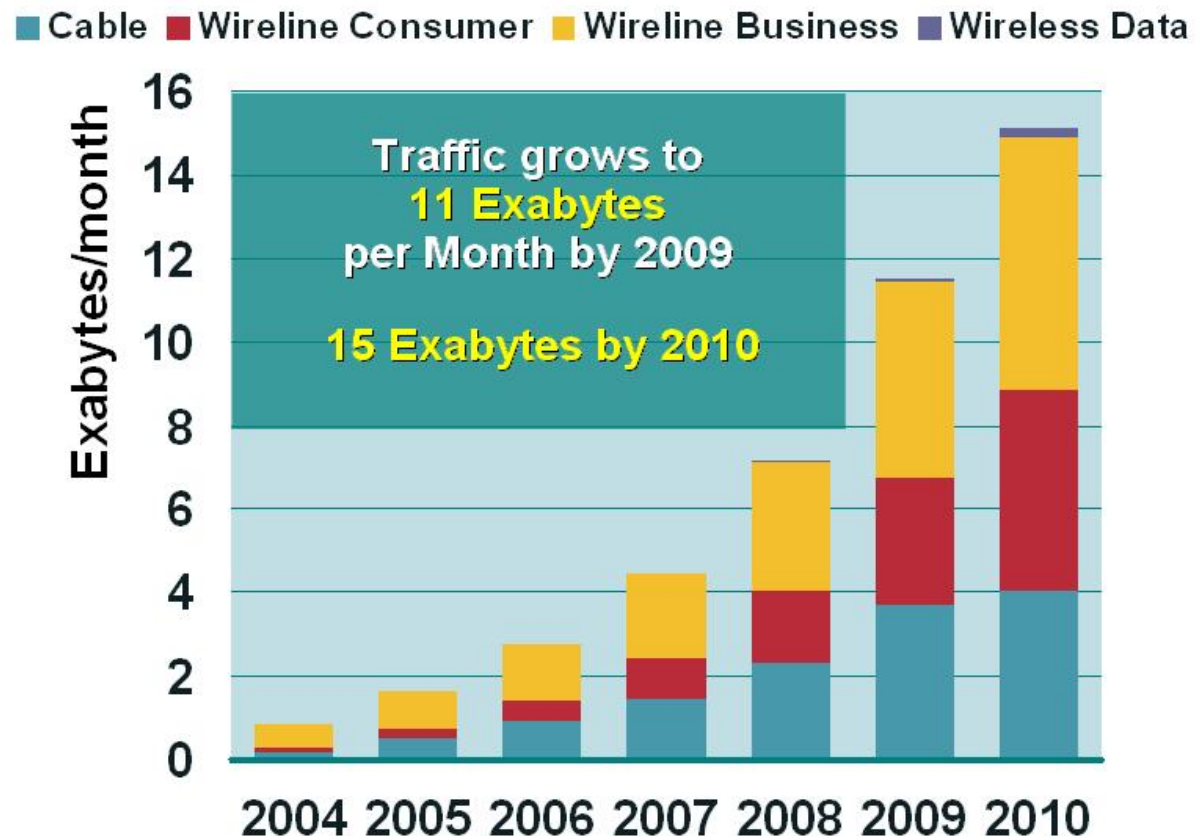
For Perspective:

1 Exabyte = 5 X
All the World's
Printed Matter

5 Exabytes =
All Words
ever Spoken

ExaByte = 10^{18}

ZetaByte = 2^{70} bytes



*Source: Cisco Estimates, Ovum, Gartner, IDC, Merrill Lynch, MRG, MPA, Public Company Data

Growth is driven exclusively by Data

- Legacy applications moving to IP

Video . SD, HD, Broadcast Cable

Voice

- New applications exclusively IP

Video - On Demand, DVRs, Switched Digital, Video conferencing

Audio . Streaming audio, Internet radio, Digital juke boxes, etc.

High-Speed Data, Internet

Over-the-Top Content providers. i.e., YouTube

- Household Bandwidth Needs in 2010 (U.S.):

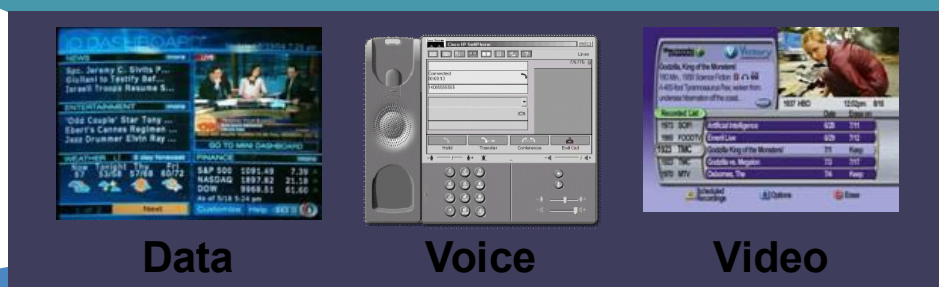
Applications: HDTV + SDTV + PVRs + HSD + VoIP-Phones

Twenty such homes would generate more traffic than traveled the entire Internet backbone in 1995

[illegible]

Delivering The Connected Life

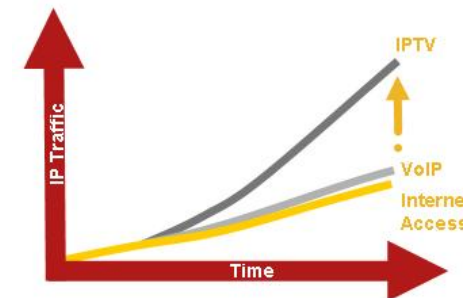
Any Content, Any Device, Any Time, Any Where



At Work, At Home, On The Move

Next Generation Core Network Questions

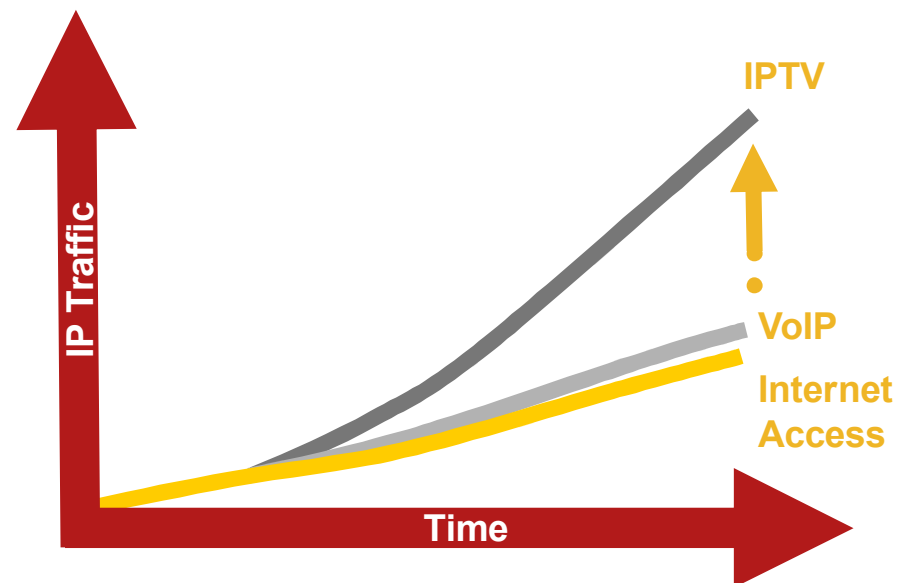
- How can network operators achieve the scalability to support the enormous bandwidth demands of the coming years?
- How can they extend intelligence throughout the network to deliver innovative services with superior quality?
- How can they move beyond the static optical networking model of the past to an environment that supports dynamic, end-to-end provisioning of any service, anywhere, any time?



Consumer Applications	Bandwidth Required
Internet	.500–1.5 Mbps
VoIP	30 Kbps–100 Kbps
Interactive Gaming	128k–6.0 Mbps
Video on Demand	3.0–6.0 Mbps
Broadcast TV (SD-TV)	3.0–5.0 Mbps
HDTV MPEG-4	6.0–7.0 Mbps

Next Generation Core Network Demands

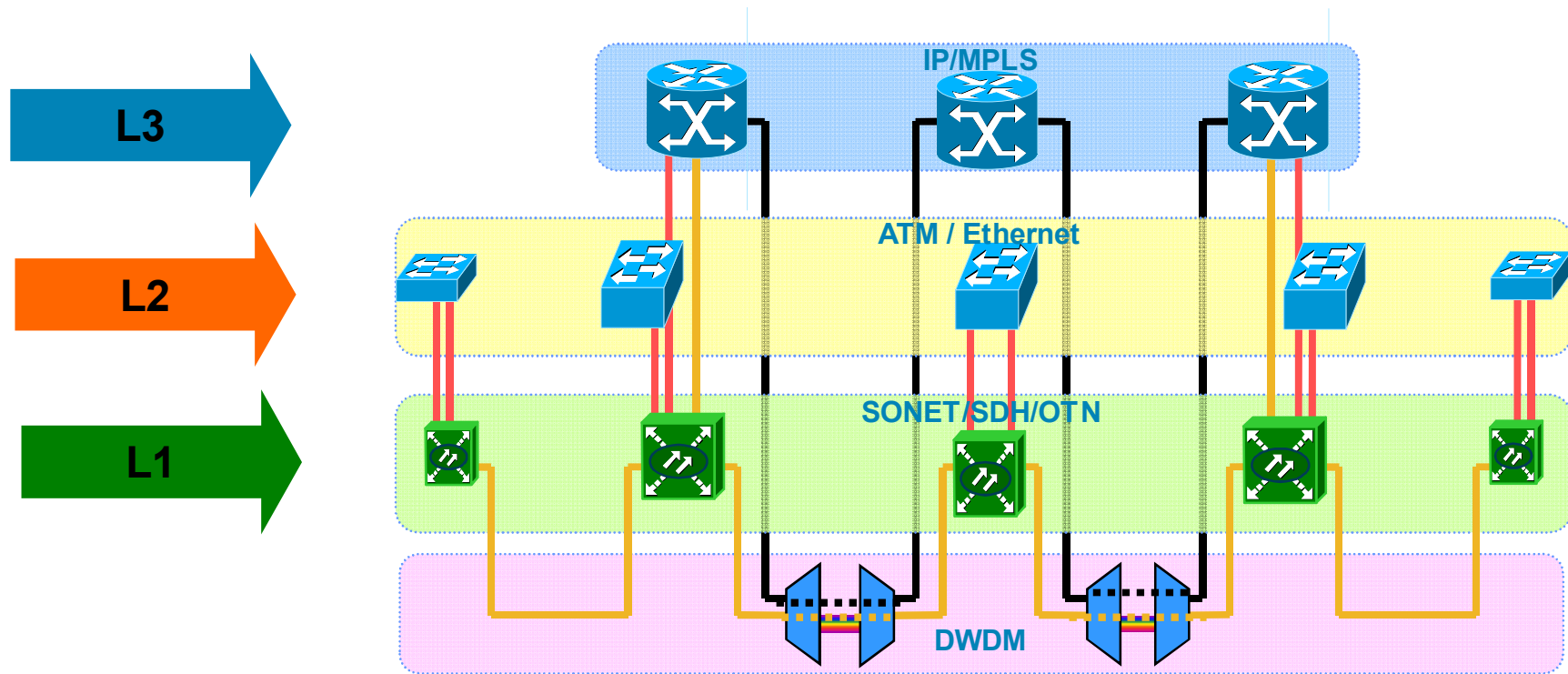
- Support for traffic growth- video/rich IP media
- Increase service flexibility- faster provisioning; new revenue generating services
- Network intelligence- automation, self optimizing
- Network agility- reconfiguration and flexibility
- Lower OpEx- simplify network and management
- Lower CapEx- increase profitability and ROI
- Increase reliability- meet SLAs for customer for customer loyalty



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Rethinking Core Transport

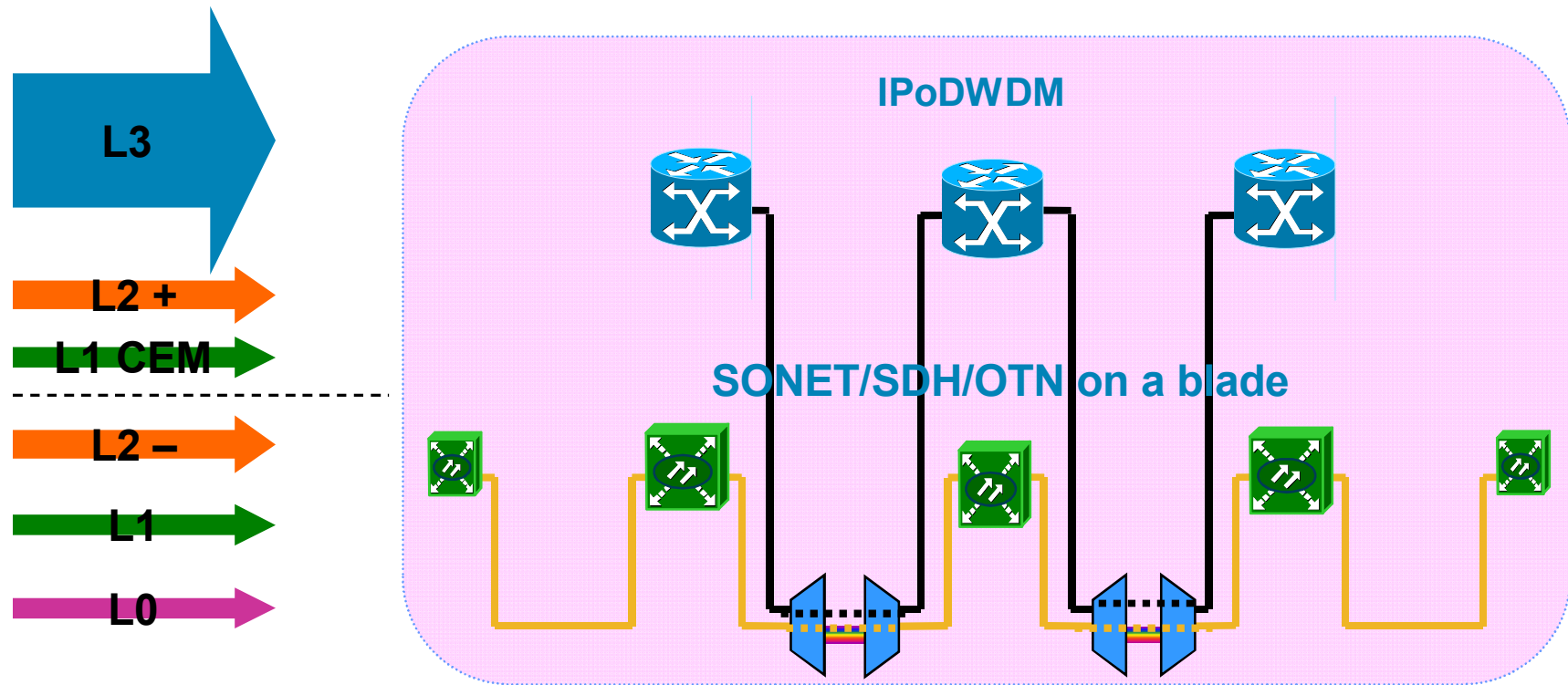
Today's Network is built around even traffic mix



- Supports all traffic
- But is not optimized for any traffic
- Complex to operate (necessary evil)

Rethinking Core Transport

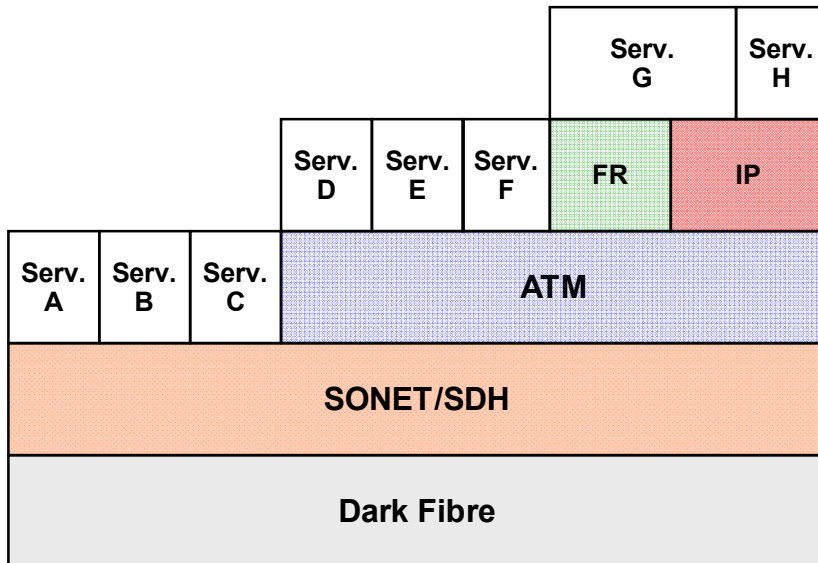
Need to optimize network architecture



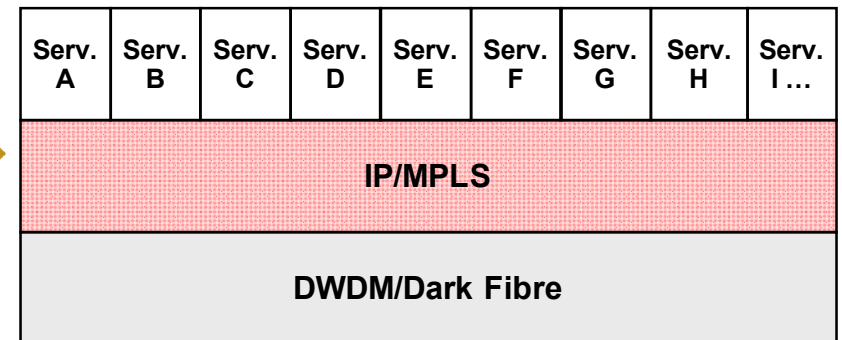
- Still supports all traffic
- But is optimized for the high growth / high bandwidth traffic
- Keep the growing part easy to upgrade / maintain
- Lower power consumption due to higher interface efficiencies

IP NGN Transport Architecture Protocol Stack

Legacy



Next Gen



- Reducing complexity and Overlap
- Simplified Transmission
- Easy to manage and evolve
- Agile time to market/deploy

